OZONE ESTIMATES WITH CURRENT AND FUTURE GOES

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Realtime GOES ozone on the web: http://cimss.ssec.wisc.edu/goes/realtime/realtime.html chris.schmidt@ssec.wisc.edu

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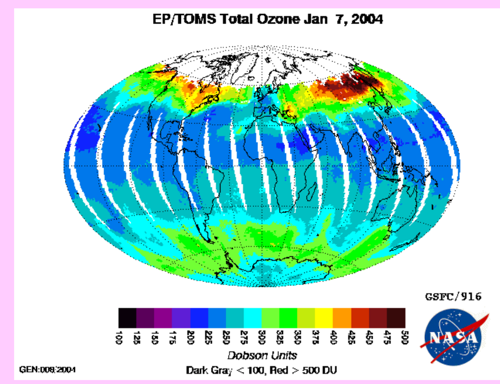
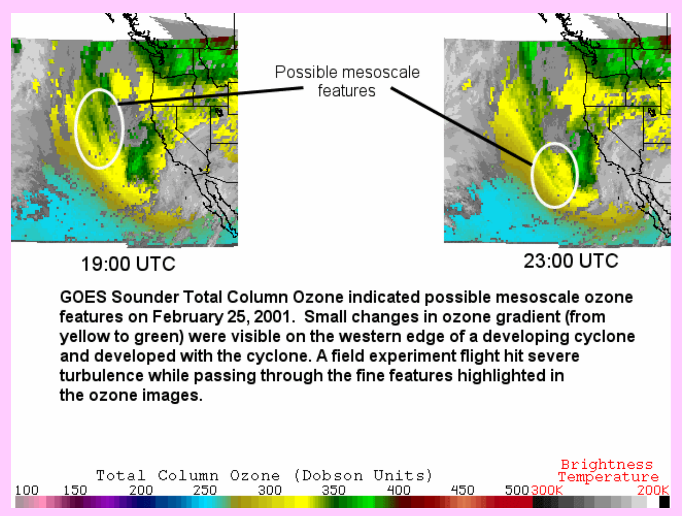
THE CASE FOR GEOSTATIONARY OZONE

Ozone is primarily viewed as a climate variable, and as a result the focus for ozone detection has been polar orbiting satellites and ground stations. However, total column ozone is correlated to potential vorticity and thus to the height of the tropopause and the sensible weather at the surface; ozone can vary as rapidly as the weather. Ozone features highlight jet streams and tropopause folds and may assist in the detection of clear air turbulence. Tropopause folds can impact air quality at the surface and thus the air quality community has an interest in monitoring ozone.

GOES has had the ability to detect ozone since GOES-8 was launched in 1994. The current GOES Sounder has a 9.7 µm band which enables the instrument to detect ozone during the day or night. Polar orbiting instruments such as the TOMS use ultraviolet wavelengths and thus are only usable during daylight. Since 1998 CIMSS has been producing total column ozone estimates utilizing a regression based approach. Currently the resolution is 10 km by 10 km (utilizing single field-of-view (fov) data from the GOES Sounder). When compared to TOMS, accuracy is on the order of 5% to 7%. GOES Sounder ozone is currently available from GOES-10/-12 for all Sounder sectors, thereby covering the continental United States every hour and surrounding oceans on a staggered schedule.



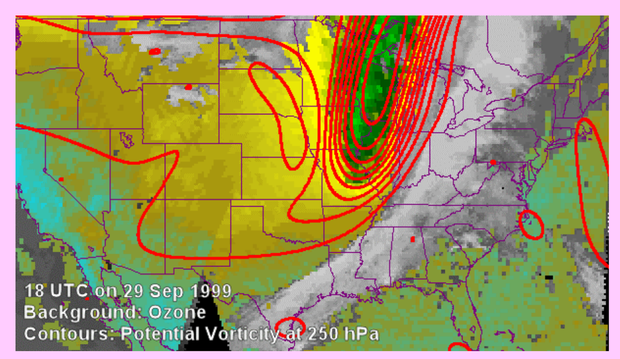
Earthprobe Total Ozone Mapping Spectrometer (TOMS) total column ozone image from 7 January 2004.



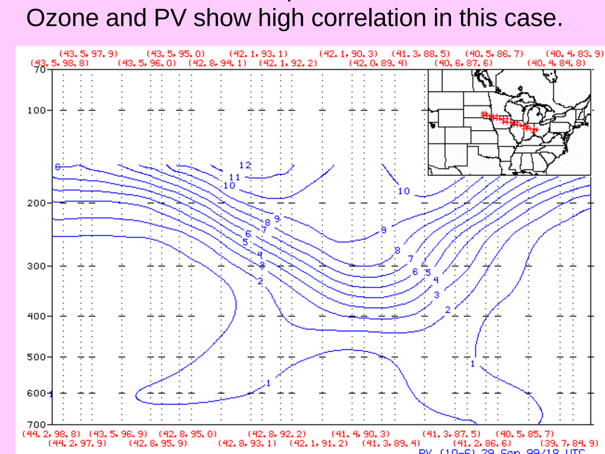
GOES Sounder Total Column Ozone indicated possible mesoscale ozone features on February 25, 2001. Small changes in ozone gradient (from yellow to green) were visible on the western edge of a developing cyclone and developed with the cyclone. A field experiment flight hit severe turbulence while passing through the fine features highlighted in the ozone images.

As in the case at left, GOES ozone has, despite its relatively coarse resolution, shown that high temporal and spatial frequency ozone imagery could assist in the detection of mesoscale features at the tropopause. Future sensors will have improved spatial resolution and better resolving power, thus mitigating the resolution problem.

This case also illustrates the degree to which ozone changes in a short period of time. The features change shape and position notably in 4 hours.

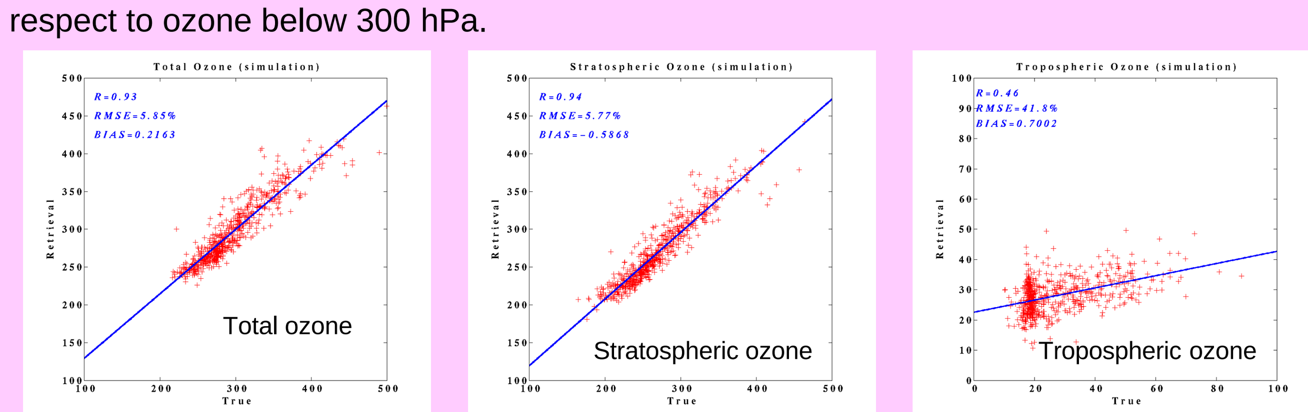


A tropopause fold is clearly visible in GOES ozone imagery and in potential vorticity derived from the ETA model on 29 September 1999 at 18 UTC. Ozone and PV show high correlation in this case.



Where’s the air quality example?!

The GOES Sounder does not have the ability to detect ozone below approximately 300 hPa. However, since the GOES Sounder ozone data is concentrated in the stratosphere a tropospheric residual can be calculated by differencing total column ozone from other sources, such as UV instruments like TOMS or the Ozone Monitoring Instrument (OMI). The simulation data presented below shows the lack of skill on the part of GOES with respect to ozone below 300 hPa.

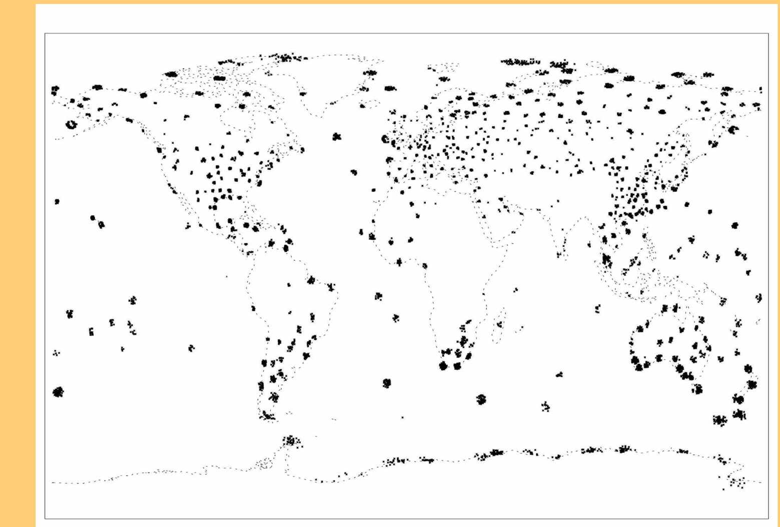


The GOES-R Air Quality Algorithm Working Group is funding work to produce an ABI ozone algorithm and to determine the best way to apply ABI ozone data to air quality issues. Instruments such as the current GOES Sounder and GOES-R ABI are unable to resolve ozone to any useful accuracy in the lower atmosphere (below roughly 300 hPa). Obtaining the tropospheric residual would require ancillary data, though total column ozone data is also useful for model assimilation, specifically as a source function for tropopause folds. Ancillary ozone data could include data from satellites such as TOMS and OMI or instruments like the HES, which may have hyperspectral coverage of the ozone region, allowing greater total column accuracy and some ability to resolve atmospheric layers of ozone.

OZONE REGRESSION ESTIMATE METHODOLOGY

The ozone regression technique used for the current GOES I-M Sounder is a simple linear regression against a profile database built from the NOAA88b set of colocated temperature, moisture, and ozone profiles as well as a few thousand others from other sources. Those profiles are used to simulate observed brightness temperatures which are then used as predictors along with other pieces of information, such as the time of year, viewing angle, and latitude. The locations of the NOAA88b profiles are indicated in the figure at the right. ABI ozone will inherit this legacy algorithm with modifications to adjust for the lack of some radiance information previously provided by the current GOES Sounder. ABI can be simulated with Meteosat-8 data given the similar bands present on both platforms.

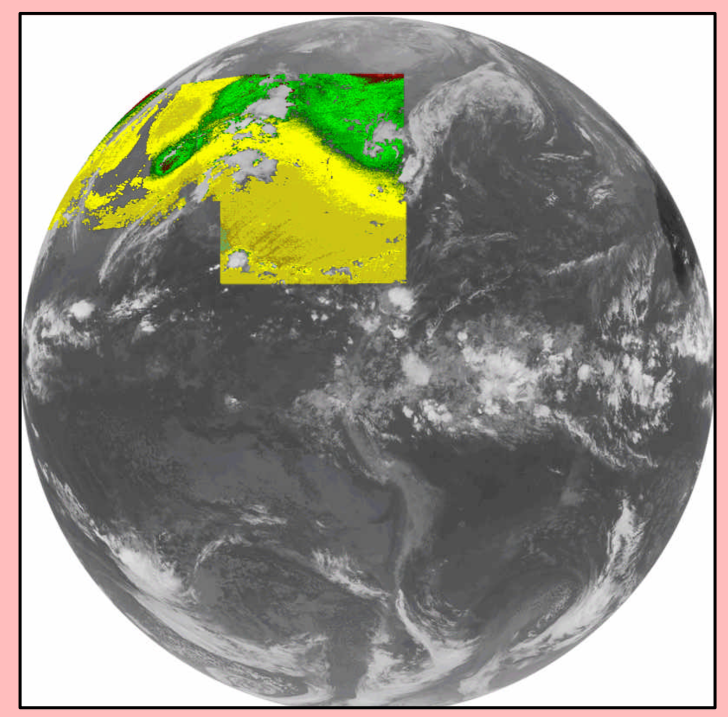
Satellite	Bands used in ozone regression
GOES Sounder	4.45, 4.53, 4.58, 6.5, 7.0, 7.5, 9.7, 11.0, 12.1, 12.7, 13.4, 13.7, 14.1, 14.4, 14.7 µm
ABI	3.9, 6.15, 7.0, 7.4, 8.5, 9.7, 10.35, 11.2, 12.3, 13.3 µm
Met-8	3.9, 6.2, 7.3, 8.7, 9.7, 10.8, 12.0, 13.4 µm



Locations of the 7,547 NOAA88b profiles

GOES-R ABI Coverage and Performance

GOES-R ABI will achieve better temporal and spatial coverage than the current GOES Sounder while attaining slightly degraded performance for total column ozone due to missing radiance information. Initial development for ABI will start with proxy data derived from Meteosat-8 and build from there.



GOES-12/-10 total column ozone from the Sounder overlaid on the coincident 11 µm Imager full disk scan. Current GOES obtains a comparable snapshot of ozone every hour.

GOES I-M:

- Hourly scans over continental US and surrounding oceans
- 8 km field-of-regard (FOR) spaced every 10 km
- Point-Spread Functions (PSFs) for some bands are much larger than the FOR, reducing resolution

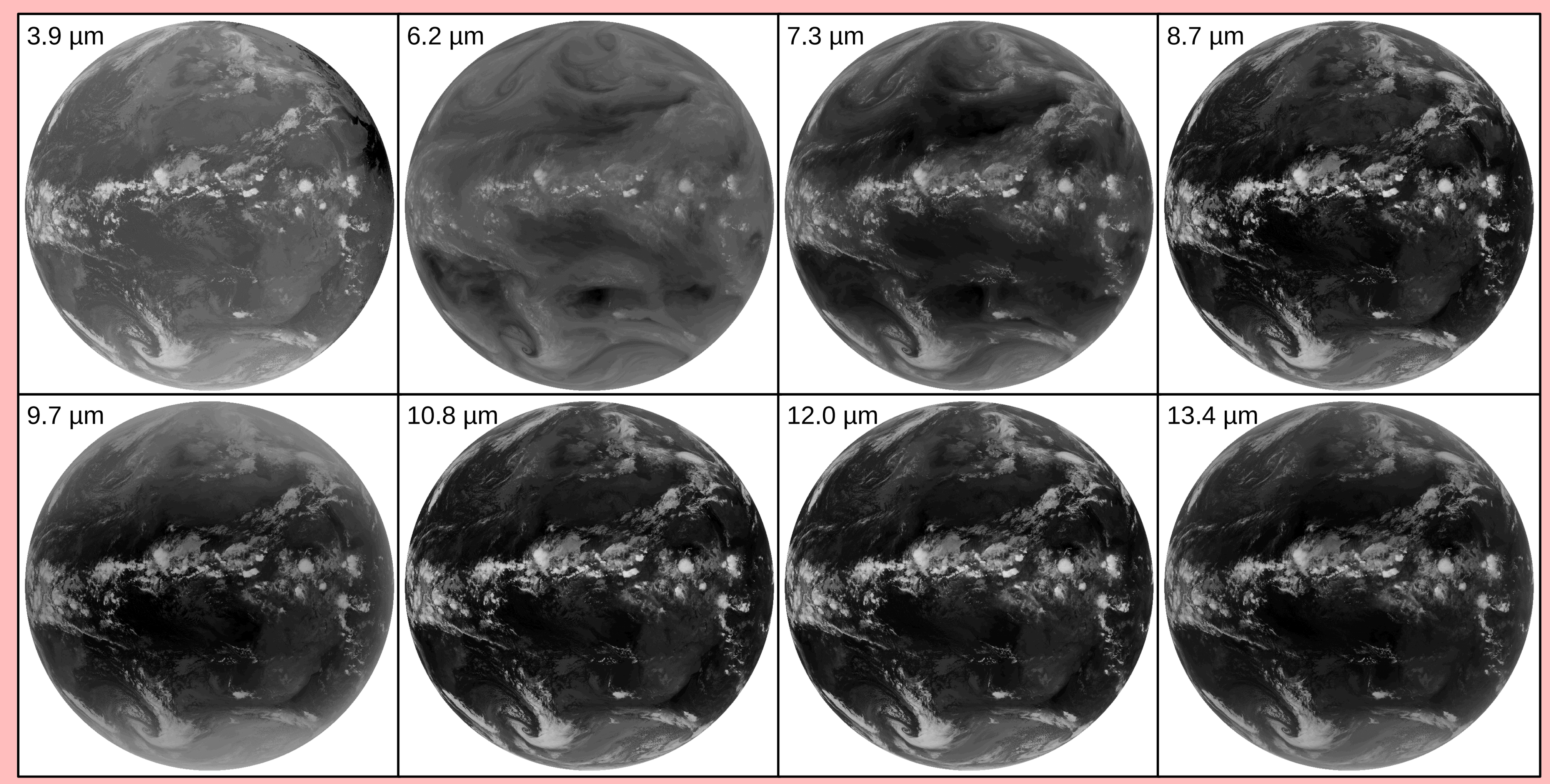
GOES-R:

- Continental US coverage every 5 minutes, full disk every 15 minutes.
- 2 km FOR spaced roughly every 2 km
- PSFs for all bands are required to be substantially better than current GOES Sounder

Calculating ABI total column ozone: Improvements over current algorithm

- Utilize time continuity to reduce noise
- Spatial averaging can also be used to reduce noise
- To expand coverage over clouds, model data may be used with quality checks based on radiative transfer calculations

Meteosat-8 IR bands, similar to ABI bands:



Absorption due to ozone shows up as colder brightness temperatures (lighter gray colors) at high latitudes in the 9.7 µm band. Similar cooling is not visible in the other IR bands, providing the foundation for isolating ozone..

ABI=**A**dvanced **B**aseline **I**mager, next generation imager planned for GOES-R

HES=Hyperspectral Environmental Suite, next generation sounder planned for GOES-R

GOES=**G**eostationary **O**perational **E**nvironmental **S**atellite, GOES-8 launched in 1994, GOES-10/-12 are currently operational